University of Saskatchewan
EP 155 – Electric and Magnetic Circuits
Final Examination

April 16, 2003

Time: 2:00 pm – 05:00 pm

Student's Name: (Print) _____

Student Number: _____

Section (circle): **Section 2** (1:00 – 2:30 pm) **Section 4** (2:30 – 4:00 pm)

Instructors: J.E. Salt, E.J. Llewellyn, A.V. Koustov

Notes:

Write your name on each page in the space provided.
Please report your final answers in the spaces provided.
Please show your work in order to demonstrate that you understand the material.
If you run out of space, then clearly indicate that you are using the back of the page.
The value of each partial question is indicated in parenthesis.
One 8½×11 sheet of paper with notes on it is permitted.
The use of any handheld calculator is permitted.
Make sure that your exam contains 14 pages with 8 questions.

Useful Constants:

$k = 9.0\times10^{9}\ Nm^2C^{-2}$

$\varepsilon_0 = 8.85418\times10^{-12}\ Fm^{-1}$

$\mu_0 = 4\pi\times10^{-7}\ Hm^{-1}$

Marks for the exam
(do not write in this space)

Q1:
Q2:
Q3:
Q4:
Q5:
Q6:
Q7:
Q8
Total:

Name _____

1. Figure 1 shows equipotential contours with 4 points (A, B, C, and G) marked on it. The voltage at point A with respect to point G is $-3\frac{1}{2}$ volts. The electric field strength at point C is 11.9 volts per meter.

a) What is the voltage at point A with respect to point B? **(2 marks)**
b) Approximately, what is the magnitude and direction of the force on a test charge of + 1 micro-coulomb placed at point C? Show the force direction on the contour plot. **(2 marks)**
c) What is the approximate strength of the electric field at point A? (**2 marks)**
d) Draw the electric field line that runs through point A. **(2 marks)**
e) What are the units of the distance marked on the *x* and *y* axes of the contour plot? **(2 marks)**

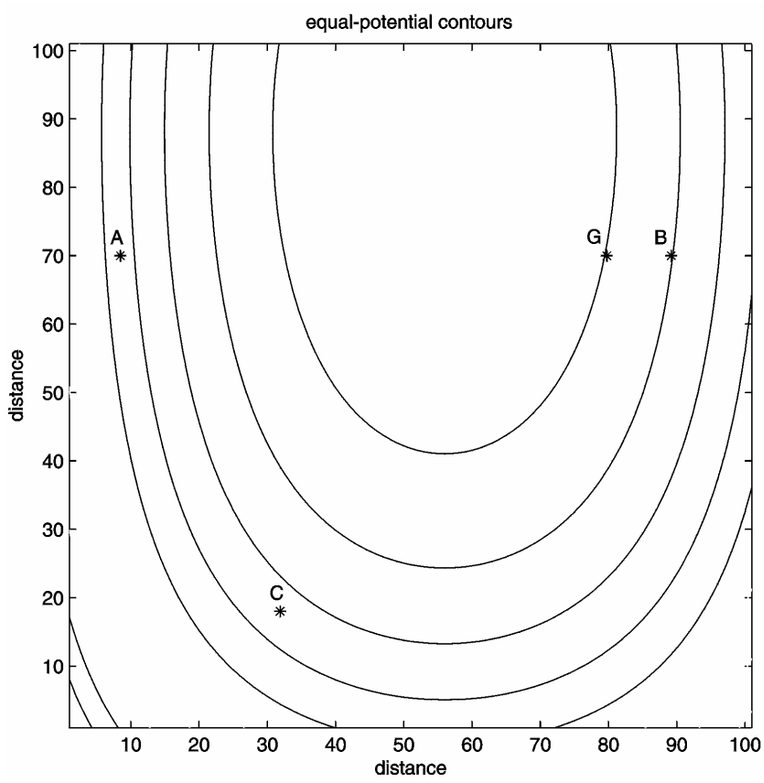


Figure 1

Name _____

2. Given the following circuit diagrams (all resistances are in ohms):

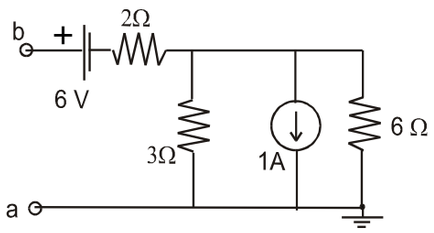


Figure 2.1

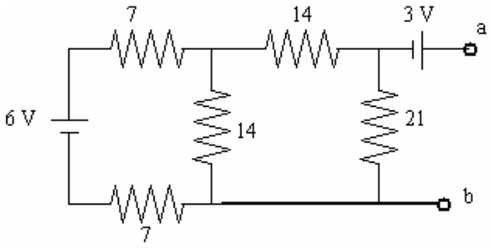


Figure 2.2

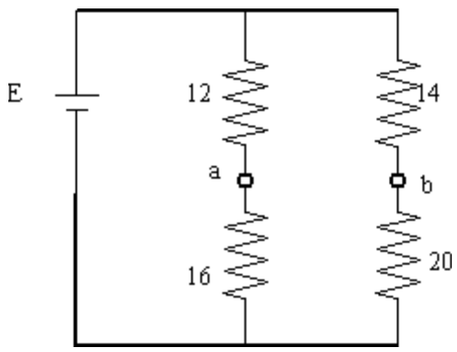


Figure 2.3

a) What is the Thevenin equivalent resistance with respect to points **a** and **b** for each of the circuits:
Figure 2.1 _____ **(1 mark)**
Figure 2.2 _____ **(1 mark)**
Figure 2.3 _____ **(1 mark)**

b) What is the Thevenin equivalent voltage V_{ab} for the circuit in
Figure 2.1_____ **(2 marks)**
Figure 2.2_____ **(2 marks)**
Figure 2.3. Assume E=28V_____ **(2 marks)**

c) What is the maximum amount of power that can be dissipated in a load resistor placed between **a** and **b** in the circuit shown in **Figure 2.3**?
_____ **(2 marks**)

Name _____

Name _____

3. Figure 3 .1 shows a circuit with two unknown components **X** and **Y.** It is known that one of these is an ideal battery while the other one is a resistor. It is also known that the current through the resistance R_4 is 0.202273 A and the voltage drop across resistor R_1 is equal to 1.18182 V. **T**he polarities marked on the two resistors are correct.

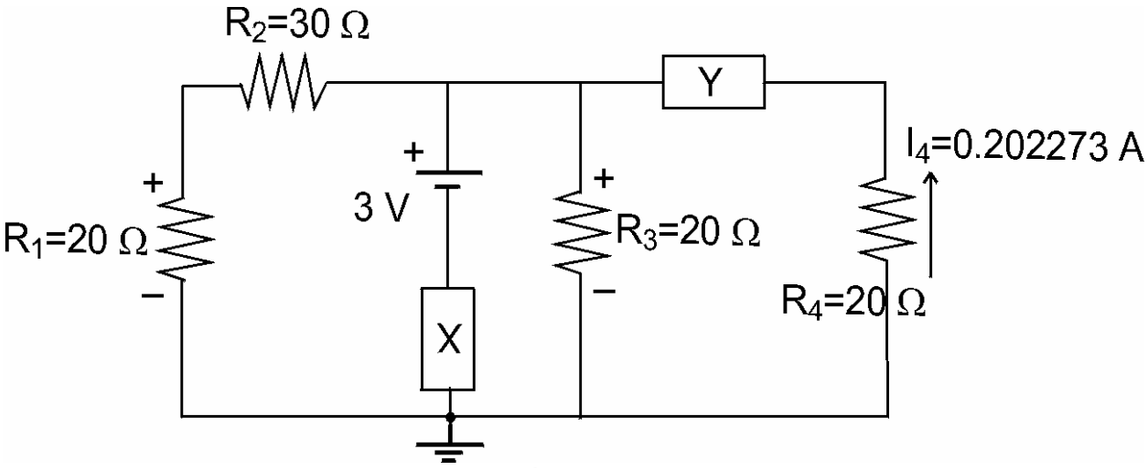


Figure 3.1

What is the current through $\mathbf{R_1}$?_____ **(1 mark)**
What is the voltage drop across $\mathbf{R_2}$ _____ **(1 mark)**
What is the voltage drop across $\mathbf{R_3}$? _____ **(1 mark)**
What is the voltage across **Y**? _____ **(1 mark)**
Is **Y** a resistor or a battery?_____ **(1 mark)**
What is the value of the component **Y**: _____ **(2 marks)**
Is **X** a resistor or a battery? _____ **(1 mark)**
What is the value of the component **X:**_____ **(2 marks)**

Name _____

Name _____

4. The circuit diagrams for two simple analog meters constructed with identical meter movements are shown in Figures 4.1 and 4.2. The voltmeter was designed to measure a maximum of **12 V** while the ammeter was designed to measure a maximum of **500 mA**. The full-scale deflection current associated with the meter movements is **1 mA**.

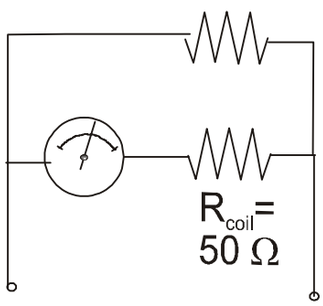


Figure 4.1

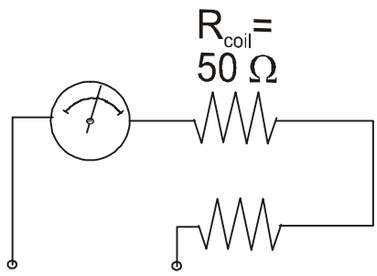


Figure 4.2

a). What is the total internal resistance of the voltmeter? _____ **(2 marks)**

b). What is the shunt resistance of the ammeter, $\mathbf{R_{shunt}}$? _____ **(2 marks)**

c). The above voltmeter is connected to the circuit shown in Figures 4.3 with the correct polarity to measure the voltage between points **a** and **b**. What does it read?

V : _____ **(4 marks)**

d). What is the loading effect of the voltmeter in the circuit shown in Figures 4.3?
(Calculate $|V_{ab}-V_{meter}|/V_{ab}$)

_____ **(2 marks)**

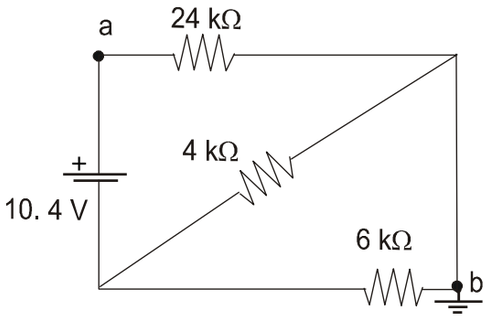


Figure 4.3

Name _____

Name _____

5. For the RC circuit shown in Figure 5.1 the switch is closed at t = 0. Initially (at the instant just before the switch is closed) the 200 nF capacitor has 12 μC of charge on it and the 300 nF capacitor is charged to 120 V.

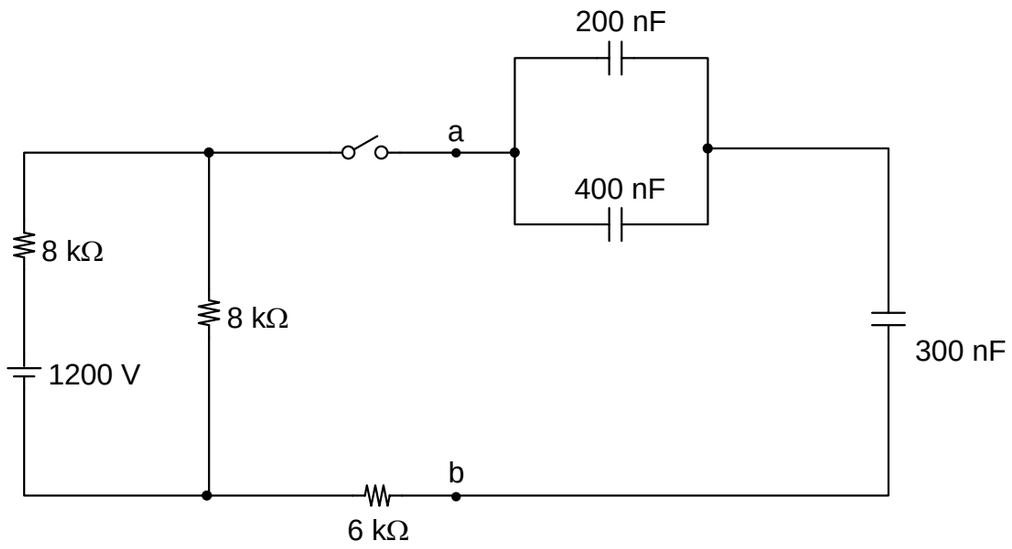


Figure 8.1

a). Find the initial charge on each of the capacitors, as well as the initial voltage across each of the capacitors. (**4 marks**)

Capacitor	Charge on Capacitor	Voltage Across Capacitor
C_1 = 200 nF	Q_1 = 12 μC	V_1 =
C_2 = 300 nF	Q_2 =	V_2 = 120 V
C_3 = 400 nF	Q_3 =	V_3 =

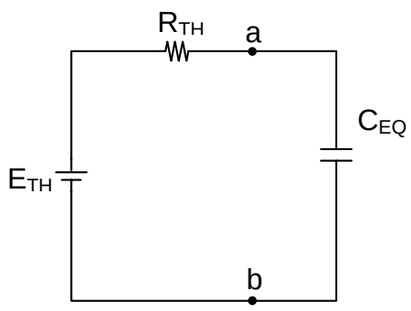
b). Find the equivalent capacitance between points ***a*** and ***b***.

_____ (**1 mark**)

c). What is the initial voltage across the equivalent capacitor (i.e. the voltage between points ***a*** and ***b*** just before the switch is closed)?

_____ (**1 mark**)

d). For the purpose of transient analysis, the circuit in Figure 5.1 after the switch is closed can be reduced to the equivalent circuit shown in Figure 5.2. Find R_{Th} and E_{Th} for the equivalent circuit (**2 marks**)



E_{TH} = _____

R_{TH} = _____

Figure 5.2

e). Roughly, how much time is needed to fully charge the 300 nF capacitor?

_____**(1 mark)**

Name _____

Name _____

6. A series magnetic circuit is shown in Figure 6. It consists of a 1000-turn coil wound around a core having two equal sections made of steel and iron with a short air gap of 0.5 cm between them. The relative permeabilities of steel and iron are μ_r = 2000 and 500, respectively. The core has a uniform cross-sectional area of 10 cm^2. The mean length of the flux path inside the core is 1.0 m. The battery has voltage E=5 volts and the resistance of the coil is R_{coil}=1 kΩ.

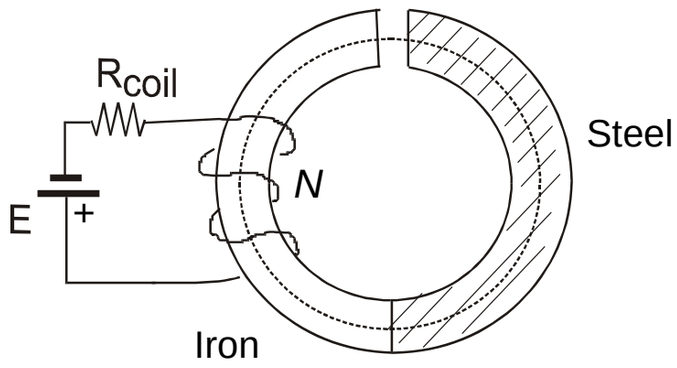


Figure 6

a). Indicate the direction of the magnetic flux established inside the core
Clockwise or **Counterclockwise** (circle your answer) _____ **(1 mark)**
b). What is the reluctance of the iron section of the core?_____ (**2 marks**)
c). What is the reluctance of the steel section of the core?_____ (**2 marks**)
d). What is the reluctance of the air gap?_____ (**2 marks**)
e). What is the magnetic flux in the core? _____ (**2 marks**)
f). What is the magnetic flux density in the air gap?_____ (**2 marks**)

Name _____

7. The circuit shown in Figure 7 is in steady-state (all transients are over):

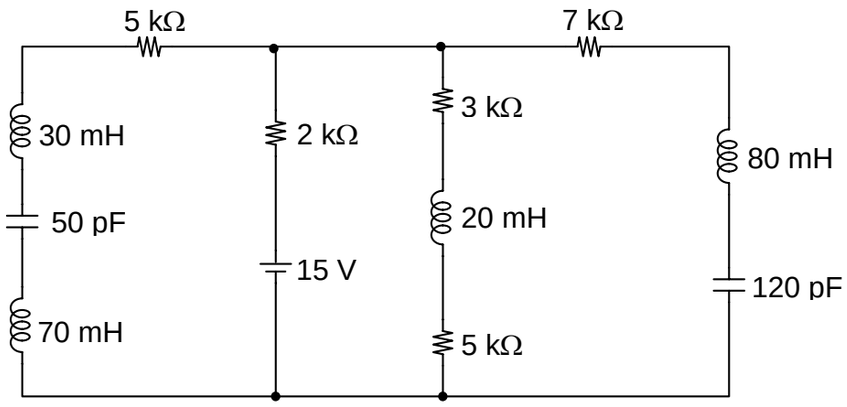


Figure 7

a) Find the following parameters:

Magnitude of I_{30mH} =_____ (**1 mark**)

Magnitude of i_{20mH} =_____ (**1 mark**)

Magnitude of v_{50pF} = _____ (**1 mark**)

Magnitude of v_{80mH} = _____ (**1 mark**)

b) Find the energy stored in the following circuit elements:

20 mH inductor _____ (**2 marks**)

30 mH inductor _____ (**2 marks**)

50 pF capacitor _____ (**2 marks**)

Name _____

8. In the RL circuit shown in Figure 8.1 the switch is closed at time **t = 0 s**

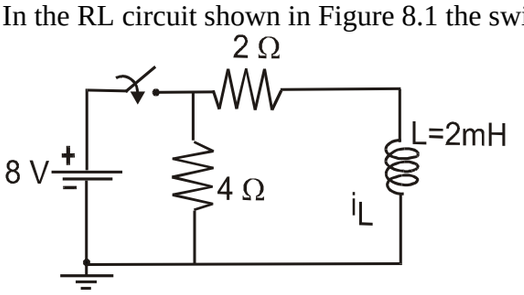


Figure 8.1

a). What is the voltage across the inductor immediately after the switch is closed?

_____ **(1 mark)**

b). What is the voltage across the 2 Ω resistor immediately after the switch is closed?

_____ **(1 mark)**

c). Give the mathematical expression for the current through the 4 Ω resistor as a function of time.

_____ **(2 marks)**

d) At what time will the energy stored in the inductor reach 95% of its final value?

_____ **(2 marks)**

In the circuit shown in Figure 8.2, the switch is opened at time **t=0.** The temporal variation of the voltage across the inductor is represented by the diagram shown in Figure 8.3.

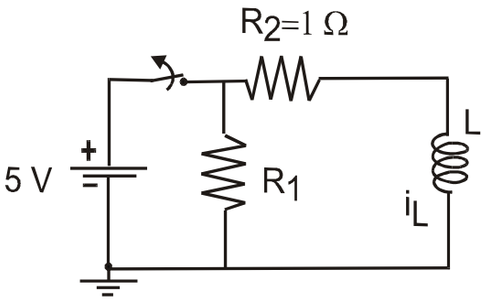


Figure 8.2

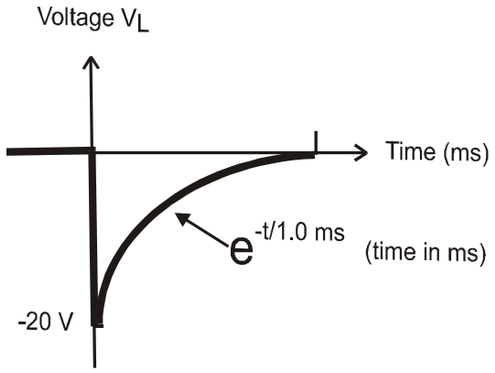


Figure 8.3

a). What is the value of R_1? _____ **(1 mark)**

b). What is the value of L? _____ **(1 mark)**

c). What is the current magnitude at **t=0**$^+$? _____ (**1 mark**)

d). What is the current direction at **t=0**$^+$? _____ (**1 mark**)

Name _____